ENERGY ENGINEERING ANALYSIS PROGRAM
100TH ASG
GRAFENWÖHR AND VILSECK, GERMANY

ENERGY AUDIT OF DINING FACILITIES

FINAL REPORT
AUGUST 1993

GRAFENWÖHR & VILSECK, GERMANY
DINING FACILITIES

VOLUME I

EXECUTIVE SUMMARY

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PREPARED FOR:

U.S. ARMY ENGINEER DISTRICT, EUROPE
CONTRACT NO. DACA-90-D-0065
DELIVERY ORDER #0006

PREPARED BY:

GEHRMANN CONSULT GMBH
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D6200 WIESBADEN, GERMANY

BAKER AND ASSOCIATES
420 ROUSER ROAD
CORAOPOLIS, PA 15108, U.S.A.

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TAB 1 - INTRODUCTION

This document is the executive summary for the Energy Audit and Subsequent Energy/Cost Analyses performed by Gehrmann Consult, GMBH and Baker And Associates (hereinafter, the Engineers) under U.S. Army Engineer District, Europe (hereinafter, EDE) contract DACA-90-D-0065. The study was performed on two dining facilities of the 100th ASG command, Building 101 at Grafenwöhr, Germany and Building 603 at Vilseck, Germany. This project was conducted as part of the Department of the Army's Energy Engineering Analysis Program (EEAP).

The overall objective of this report is to identify and develop projects that can reduce the energy consumption of the aforementioned dining facilities. These projects are to be in compliance with the objectives of the Army Facilities Energy Plan (AFEP) and are to, in no way, decrease the readiness posture of the Army.

This study has been prepared in compliance with the General Scope of Work (SOW) dated 8 May 1992 and revised 1 September 1992 and its accompanying detailed Scope of Work. The complete SOW is included in this report as Appendix A in Volume III. All of the ECO's identified and developed under this contract are listed in Section 5 of the Executive Summary. The calculated Savings to Investment Ratios (SIRs) and the relative rankings of the ECO's are also listed in Section 5 of this Volume.

ECO's were identified during a four-day visit to the project sites in late November and early December of 1992. The ECO's identified were broken into five categories (i.e., Architectural, Electrical, Mechanical-HVAC, Mechanical-Plumbing, and Maintenance and Operations). The ECO's most suitable for rigorous evaluation were then identified and the energy/cost savings calculated. In addition Low/No Cost ECO's were identified and analyzed. Unfortunately, due to the newness of their construction and the energy-saving designs of both facilities, relatively few ECO's were available for the audit team to analyze. Fortunately, this indicates that both facilities are well designed, constructed, and operated.

The financial analysis of each ECO was conducted in accordance with the CEHSC-FU-M memorandum, "Energy Conservation Investment Program (ECIP) Guidance", dated 4 November 1992. All projects were assumed to be funded and constructed in 1993. Savings-to-Investment Ratio (SIR) calculations were performed in accordance with National Institute of Standards and Technology (NIST) Handbook 135, "Life Cycle Cost Manual for the Federal Energy Management Program." A Uniform Present Worth (UPW) discount factor of 4.0 percent and the U.S. average commercial fuel price escalation rates were used in all SIR calculations.

TAB 2 - SITE AND BUILDING DATA

2.1 General Description of Grafenwöhr/Vilseck Area

2.1.1 The U.S. Army training bases at Grafenwöhr and Vilseck lie on opposite sides of the Seventh Army Training Command, which is the largest training area in Europe. The climate is moderate with normally warm summers and cool, foggy autumns. Winter is cold and sunny, although the temperature seldom drops below -17.8° C (0°F).

2.2 General Description of Grafenwöhr Building 101

2.2.1 Grafenwöhr Building 101 is a one-story, red brick faced building with a flat roof. The building was constructed in 1982. It has a single, 250m^2, dining area with a smaller, 100m^2, dining area adjacent to it. This smaller dining area was added onto the original building in 1991.

2.2.2 The building has a single troop entrance with a small vestibule. Upon entering, the troops are directed to a single hot food serving line and two drink serving lines. The food preparation area, pot scrub area, and the walk-in freezers lie directly behind the serving area. The dishwashing area lies along one side of the serving area and adjacent to the dining area. The mechanical equipment room, the service entrance, and the refrigeration equipment room are spread along the opposite side of the building from the dining areas.

2.2.3 There are three air handling units located in the aforementioned mechanical equipment room. These serve the Dining Area, the Serving Area, and the Kitchen. All three units are heating-only units. Because the summers are so mild, air conditioning is not permitted or required at this location.

2.2.4 The mechanical room also houses the domestic hot water heater/storage tank, all pumps for domestic and heating hot water, and the building's energy management control panel.

Pump sets, drawing from a district hot water supply manifold, provide hot water to the three air handling units, the domestic hot water heat exchanger, and the perimeter baseboard radiation system.

2.2.5 Lighting in the Dining Area is provided by recessed, three-lamp fluorescent fixtures. A string of single-tube fluorescent fixtures is located in a lighting cove around the perimeter of the Dining Area. Fluorescent fixtures are used to light the remainder of the building.

2.3 General Description of Vilseck Building 603

2.3.1 Vilseck Building 603 is a one-story, yellow brick faced building with three peaked roofs running the width of the building. The building has two dining areas, one on either side of the building. A dishwashing area occupies the front-central portion of the building and the serving area occupies the rear-central portion of the building. Each dining area is served by its own hot food line. Along the front of the building there are two toilet rooms and an entry corridor. The entry corridor is accessed from either side of the building and serves both dining areas. Behind the serving area is the kitchen, or food preparation area. The pot scrub area, the refrigeration compressor room, the walk-in refrigerator and freezer, central stores, the electrical equipment room, the mechanical equipment room, and the employees shower are all wrapped around the food preparation area at the rear of the building. The building was completed in 1986.

2.3.2 There are five, heating-only, air handling units serving the following areas: the kitchen, the serving area, the dishwashing area, the east dining room, and the west dining room. Each unit is located in the attic space over the area it serves. In addition to these five main air handling units, there are eleven ventilation units which are connected to the various exhaust hoods within the building. These units are not equipped with heating coils. The building's energy management control panel is also located in the attic space.

2.3.3 The mechanical equipment room houses two domestic hot water heating/storage tanks and the pumps for the domestic and the heating hot water systems.

2.3.4 Lighting in the dining area is by means of incandescent lamps mounted in architecturally dictated chandeliers. In addition, the dining area is equipped with incandescent wall washers. A string of single-tube fluorescent fixtures is located in a lighting cove around the perimeter of the dining areas. The remainder of the building is lit by recessed fluorescent lighting fixtures.

TAB 3 - PRESENT ENERGY CONSUMPTION

3.1 Energy Consumption of Grafenwöhr Building 101

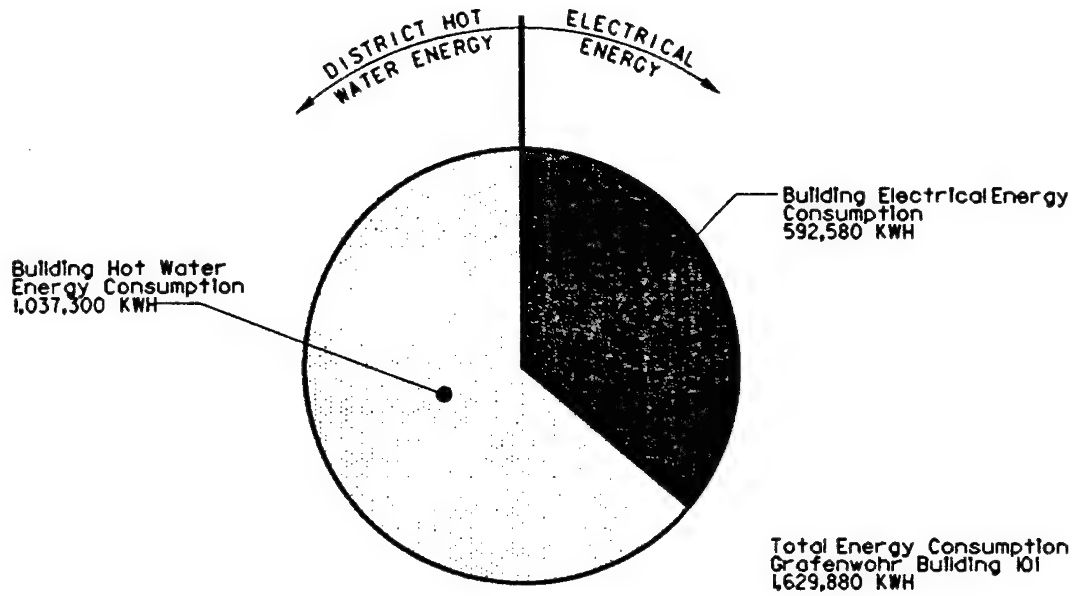
3.1.1 The total annual energy consumption at Grafenwöhr Building 101 is 1,629,880 kWh. Of this, an estimated 88 percent, or 1,434,295 kWh is mission-related energy (i.e., energy used for cooking, cleaning and dishwashing). The remaining 195,585 kWh are used for non-mission related functions such as building heating, ventilating, handwashing, lighting, etc.

3.1.2 Energy is supplied to Building 101 by two different sources - district hot water and electricity. The building consumes 1,037,300 kWh of district hot water and 592,580 kWh of electrical energy. See Figure ESF-1.

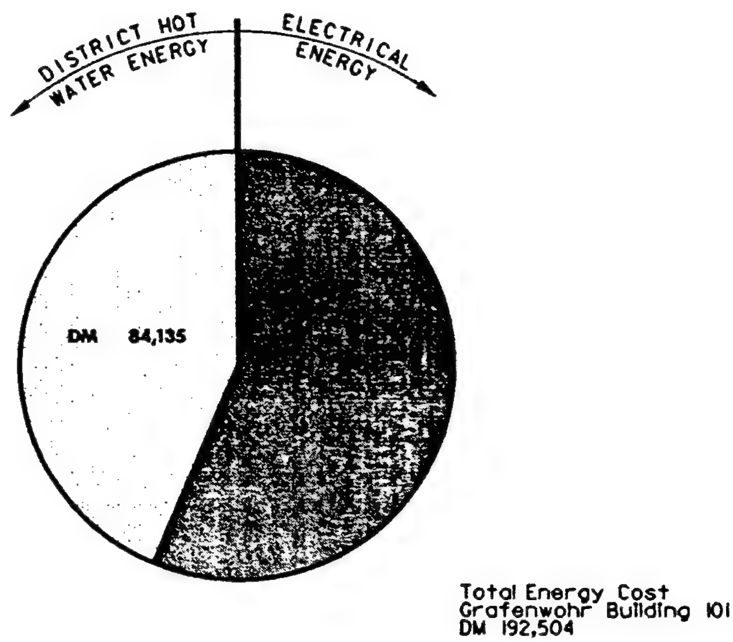
3.2 Energy Consumption of Vilseck Building 603.

3.2.1 The total annual energy consumption at Vilseck Building 603 is 3,014,800 kWh. Of this, an estimated 88 percent, or 2,653,000 kWh is mission-related energy (i.e., energy used for cooking, cleaning, and dishwashing). The remaining 361,800 kWh are used for non-mission related functions such as building heating, ventilating, handwashing, lighting, etc.

3.2.2 Energy is supplied to Building 603 by two different sources - district hot water and electricity. The building consumes 2,252,000 kWh of district hot water and 762,800 kWh of electrical energy. See Figure ESF-2.

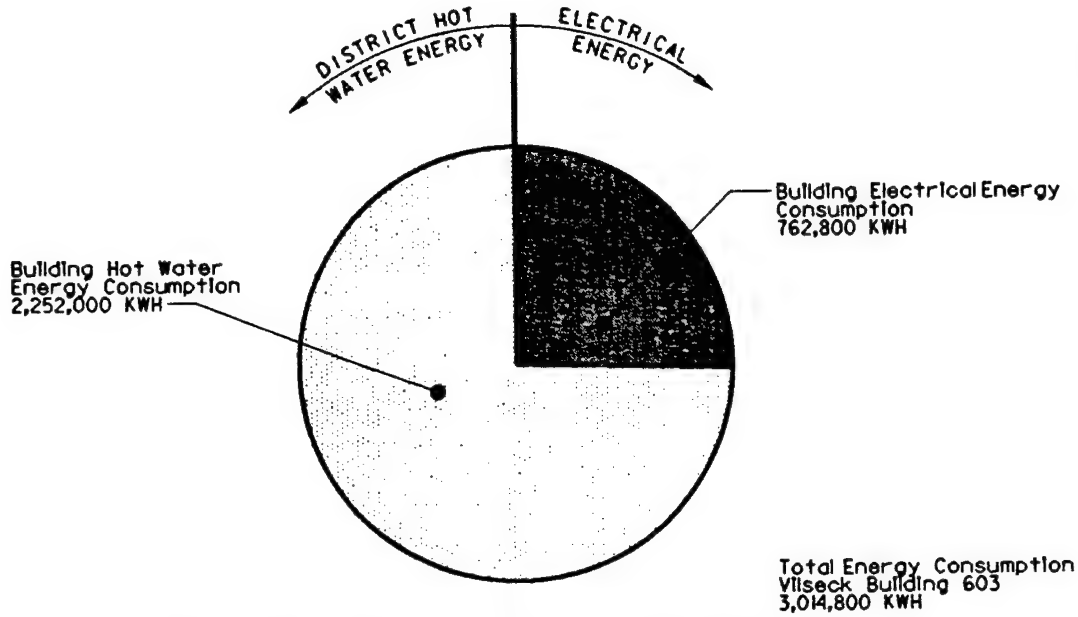


ESTIMATED ENERGY CONSUMPTION, BY USAGE

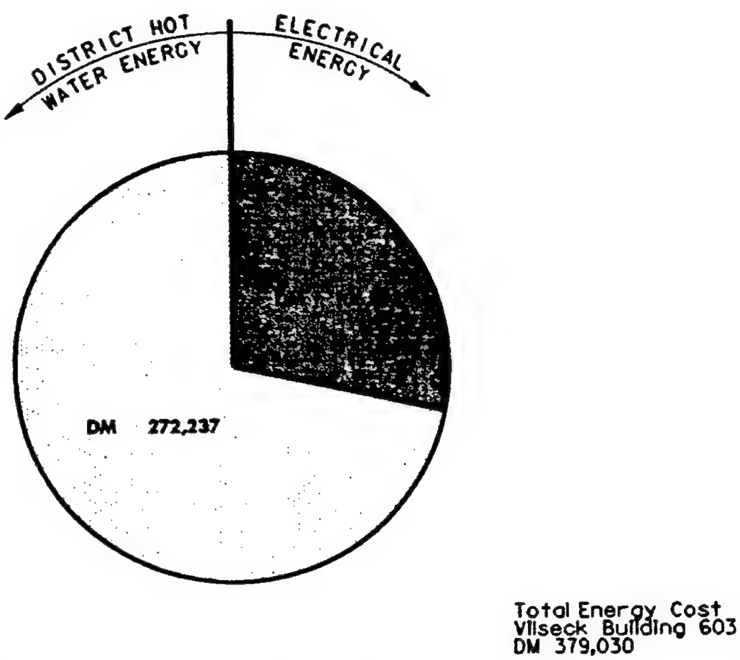


ESTIMATED ENERGY COST BY USAGE

Figure ESF-1 Annual Energy Use - Grafenöwhr Building 101



ESTIMATED ENERGY CONSUMPTION, BY USAGE



ESTIMATED ENERGY COST BY USAGE

Figure ESF-2 Annual Energy Use - Vilseck Building 603

TAB 4 - HISTORICAL ENERGY CONSUMPTION

4.1 Energy Consumption Profile - Grafenwöhr Building 101

4.1.1 The following information was obtained from meters installed in the utility service lines at Building 101. See Appendix E, Volume III, for development of consumption data.

TABLE EST-1 - METERED ENERGY CONSUMPTION GRAFENWÖHR BUILDING 101

MONTH/YEAR	ELECTRICAL CONSUMPTION (KWH)	DISTRICT HOT WATER (KWH)
January/1993	47,070*	112,800*
February/1993	47,070*	112,800*
March/1993	47,070*	112,800*
April/1992	51,550**	101,700**
May/1992	56,040	90,600
June/1992	42,170	35,800
July/1992	52,160	38,400
August/1992	54,950	45,200
September/1992	47,100	57,600
October/1992	47,700	100,600
November/1992	52,630	116,100
December/1992	47,070*	112,900*

* Average consumption for four month period
** Estimate based average consumption for March 1993 and April 1992

4.1.2 The tabulated data presented above has been plotted in Figure ESF-3.

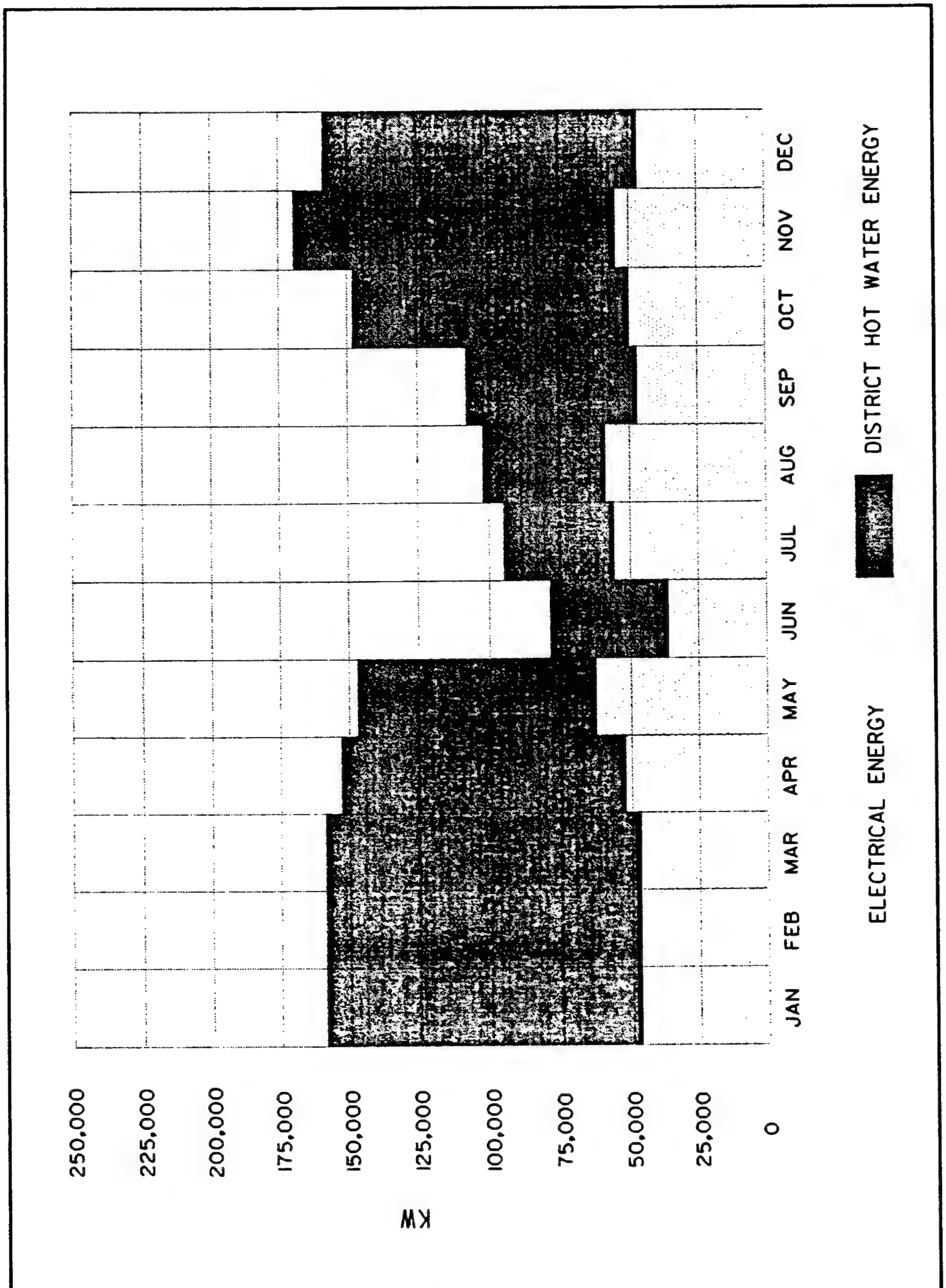


Figure ESF-3 Energy Consumption Profile - Grafenwöhr Building 101

4.2 Energy Consumption Profile - Vilseck Building 603

4.2.1 The following information was obtained from meters installed in the utility service lines at Building 603. See Appendix E, Volume III, for development of consumption data.

TABLE EST-2 - METERED ENERGY CONSUMPTION VILSECK BUILDING 603

MONTH/YEAR	ELECTRICAL CONSUMPTION (KWH)	DISTRICT HOT WATER (KWH)
January/1993	66,050*	170,000***
February/1993	66,050*	170,000***
March/1993	66,050*	170,000***
April/1993	63,550**	187,500**
May/1992	56,000	656,500
June/1992	62,500	321,000
July/1992	64,750	58,000
August/1992	64,750	45,000
September/1992	55,000	150,000
October/1992	66,000*	77,000****
November/1992	66,050*	77,000****
December/1992	66,050*	170,000***

* Average consumption for six month period
** Average based on preceding eleven months
*** Average consumption for four month period
**** Average consumption for two month period

4.2.2 The tabulated data presented above has been plotted in Figure ESF-4.

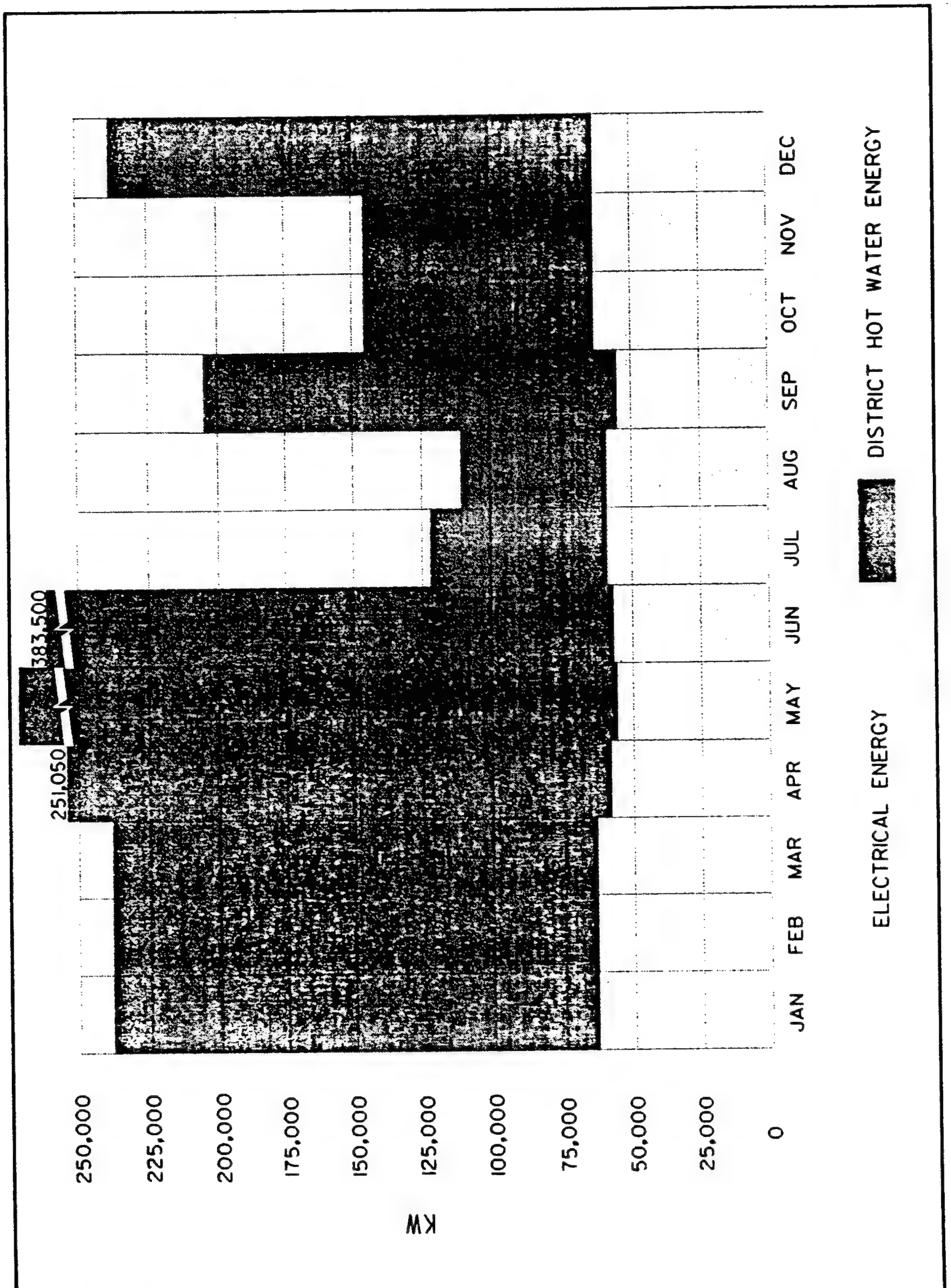


Figure ESF-4 Energy Consumption Profile - Vilseck Building 603

TAB 5 - ENERGY CONSERVATION ANALYSIS

5.1 Energy Conservation Opportunities Investigated

5.1.1 Architectural Energy Conservation Opportunities (ECO's) consist, mainly of those ECO's which will improve the thermal efficiency of the building envelope. The following twelve architectural ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

A1. Conserve energy by increasing the insulation in exterior walls.

A2. Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.

A3. Conserve energy by reducing the amount of window glass in exterior walls.

A4. Conserve energy by installing insulated panels over exterior windows.

A5. Conserve energy by replacing single pane window glass with double or triple pane window glass.

A6. Conserve energy by installing storm windows over exterior windows.

A7. Conserve energy by installing solar film on exterior windows.

A8. Conserve energy by installing shades, screens, curtains or blinds on exterior windows.

A9. Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.

A10. Conserve energy by installing vestibules at troop entrances.

A11. Conserve energy by installing air curtains or plastic strips at all service entrances.

A12. Conserve lighting energy by improving the reflectivity of room surfaces.

5.1.2 Heating, Ventilating, and Air Conditioning (HVAC) system ECO's consist of changes which will improve the efficiency of the HVAC System (i.e. - air handling units, exhaust fans, piping, ductwork, etc.) and the HVAC system controls. The following twenty-five HVAC system ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

H1. Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.

H2. Conserve energy by recovering waste heat from exhaust air streams.

H3. Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.

H4. Conserve energy by balancing the HVAC system.

H5. Conserve energy by reducing the amount of air supplied to or exhausted from the building (or space).

H6. Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.

H7. Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).

H8. Conserve energy by reducing static pressure in HVAC systems.

H9. Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.

H10. Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.

H11. Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.

H12. Conserve energy by recovering waste heat from refrigeration systems.

H13. Conserve energy by ventilating the refrigeration system compressor room.

H14. Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.

H15. Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.

H16. Conserve energy by reducing pump flow rates.

H17. Conserve energy by installing new insulation, adding additional insulation, or repairing existing insulation on heating hot water piping.

H18. Conserve energy by repairing or eliminating all HVAC system control deficiencies.

H19. Conserve energy by using an Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.

H20. Conserve energy by using an EMCS to set-back space temperatures at night during the heating season.

H21. Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.

H22. Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.

H23. Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.

H24. Conserve energy by shutting off or reducing the amount of heating in vestibules.

H25. Conserve energy by installing a thermal storage system.

H26. Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.

5.1.3 Plumbing System ECO's consist of changes which will improve the efficiency and/or reduce the energy consumption of the plumbing systems (i.e. - Domestic cold water, hot water and waste water systems). The following ten plumbing ECO's were investigated at both the Grafenwöhr and Vilseck sites.

P1. Conserve energy by lowering the domestic hot water supply temperature.

P2. Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak periods.

P3. Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.

P4. Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.

P5. Conserve energy by installing additional insulation on the domestic hot water storage tanks.

P6. Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.

P7. Conserve energy by installing flow restrictors at domestic hot and cold water end users.

P8. Conserve energy by installing automatic shut-off type faucets in lavatories.

P9. Conserve energy by reclaiming waste heat from dishwasher wastewater.

P10. Conserve energy by installing solar collectors to pre-heat domestic hot water.

5.1.4 Electrical System ECO's consist of changes which will improve the efficiency and/or reduce the energy consumption of the electrical system (i.e. - power distribution and lighting systems). The following twenty electrical ECO's were investigated at both the Grafenwöhr and the Vilseck sites.

E1. Conserve energy by reducing lighting levels to minimum levels described in the Army Design Guidelines.

E2. Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.

E3. Conserve energy by delamping selected lighting fixtures.

E4. Conserve energy by converting existing lighting fixtures to high efficiency fluorescent or HID fixtures.

E5. Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.

E6. Conserve energy by installing improved reflectors on lighting fixtures and reducing the fixtures lamp wattage.

E7. Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.

E8. Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.

E9. Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.

E10. Conserve energy by installing dimming hardware on exterior HID lighting.

E11. Conserve energy by turning exterior lighting "on" and "off" by means of photocells.

E12. Conserve energy by turning exterior lighting "on" and "off" by means of timers.

E13. Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.

E14. Conserve lighting energy by using photocells to turn "off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.

E15. Conserve energy by turning interior lighting "on" and "off" by means of timers.

E16. Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.

E17. Conserve energy by replacing existing motors with energy efficient motors.

E18. Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.

E19. Conserve energy by adding power factor correcting capacitors to existing motors.

E20. Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.

5.1.5 Operations and Maintenance (O & M) ECO's consist of changes to the procedures which govern the use and maintenance of the dining facility and the equipment therein. Most O & M ECO's can be classified as Low/No Cost ECO's and are, therefore, of special interest to the facility managers and users. Many O & M ECO's may be put into effect by installing time clock controls at some later date, however, all of the proposed O &

M ECO's can be put into effect immediately, through the efforts of the kitchen and maintenance staffs. The following twenty-one O & M ECO's have been investigated at both the Grafenwöhr and Vilseck sites.

OM1. Conserve energy by optimizing HVAC system start-stop times and set-back temperatures with respect to dining facility operations.

OM2. Conserve energy by maintaining thermostat set-points at authorized temperatures.

OM3. Conserve energy by turning "off" kitchen hot water heaters (specifically booster heaters on dishwashing equipment) when not required.

OM4. Conserve energy by shedding or cycling electrical loads to reduce peak demand.

OM5. Conserve energy by running the emergency generator to reduce peak demand.

OM6. Conserve energy by maintaining all HVAC system controls in good working order.

OM7. Conserve energy by keeping the coils (both evaporator and condenser) on all refrigeration equipment clean and unobstructed.

OM8. Conserve energy by keeping the heat exchanger tubes in the domestic hot water heater clean. Provide water treatment if required to prevent fouling of tube surfaces.

OM9. Conserve energy by keeping all light fixture lenses and reflectors clean.

OM10. Conserve energy by keeping all HVAC system filters (including exhaust hood grease filters) clean.

OM11. Conserve energy by turning "off" all miscellaneous electrical equipment (such as vending machines) whenever it is not required.

OM12. Conserve energy by consolidating refrigerated foodstuffs into fewer refrigerators, coolers, or freezers and turning "off" those freezers that are not required.

OM13. Conserve energy by thawing frozen foods in refrigerated compartments.

OM14. Conserve energy by preheating only that equipment which will be required for the meal being served.

OM15. Conserve energy by preheating equipment immediately prior to use.

OM16. Conserve energy by steaming (rather than boiling) vegetables whenever possible.

OM17. Conserve energy by matching pots to burner size so that pots completely cover burners.

OM18. Conserve energy by cooking with lids in place.

OM19. Conserve energy by using microwave cooking equipment in lieu of conventional cooking equipment whenever possible.

OM20. Conserve energy by avoiding the use of hot water for dish scraping.

OM21. Conserve energy by operating dishwashers only when continuous usage can be sustained.

OM22. Conserve energy by reducing the building's operating hours.

OM23. Conserve energy by conducting regular steam trap inspections.

5.2 ECO's Recommended for Grafenwöhr Building 101

5.2.1 The implementation of the following ECO's is recommended for Grafenwöhr Building 101. Note: All ECO's listed in the Table below were evaluated in FY93 for implementation in FY93.

TABLE EST-3 RECOMMENDED ECO'S FOR GRAFENWÖHR BUILDING 101

ECO NO.	ENERGY SAVINGS (MBTU/YR)*	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	87.2	DHW	2,669	32	1418	<0.1
E1	24.8	E	1,031	808	14.79	1.3
P5	5.5	DHW	169	549	5.30	3.2
E10	9.2	E	381	1,546	2.85	4.1
P8	5.2	DHW	159	1,210	2.26	7.6
H17	6.4	DHW	196	3,226	1.04	16.5
E14	7.4	E	309	3552	1.01	11.5

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.2.2 Operations and Maintenance ECO's have not been included in the chart above. However, it is the opinion of the audit team that OM ECO's Nos. 3, 4, and 11 through 22 should all be implemented by training the kitchen staff. All of these ECO's, while clearly energy savers, are difficult, if not impossible, to evaluate for energy savings. There are, simply, too many assumptions which would have to be made to evaluate these

5.2.3 The following operating and maintenance deficiencies were observed at Grafenwöhr during the site survey team's stay there.

1. The exterior fluorescent lights at the loading dock were turned on during the day.

2. The lighting in the dishwashing area was left on at all times.

3. The cove lighting in the dining area and approximately half of the dining room lighting was left on throughout the day

5.2.4 The Army should, on a regular basis, update the training of the Dining Facility staffs - both cooking and maintenance staffs - as to energy saving practices. In addition, the Army should re-evaluate the use of the Dining Facility. Specifically, does the number of meals served warrant the number of hours that the building is kept open? Can the baking staff work between meals or during the cleanup period rather than at night? Can one dining area be left unused during low volume meals such as breakfast and weekend meals? These practices can yield significant energy savings without affecting the facility's mission if they are implemented carefully.

5.3 ECO's Recommended for Vilseck Building 603

5.3.1 The implementation of the following ECO's is recommended for Vilseck Building 603. Note: All ECO's listed in the Table below were evaluated in FY93 for implementation in FY93.

TABLE EST-4 RECOMMENDED ECO'S FOR VILSECK BUILDING 603

ECO NO.	ENERGY SAVINGS (MBTU/YR)*	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	113.3	DHW	4,087	75	935	<0.1
E4B	39.6	E	1,624	18,827	15.01	0.8
H24	1.0/30.3	E/DHW	1,134	1,344	14.35	1.2
E1	44.5	E	1,825	2,020	10.47	1.1
P5	8.8	DHW	318	878	6.24	2.8
E14	9.8	E	402	768	6.07	1.9
H17	40.7	DHW	1,468	9,588	2.64	6.5
E4A	195.0	E	7,999	74,432	1.24	9.3

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.3.2 Operations and Maintenance ECO's have not been included in the chart above. However, it is the opinion of the audit team that OM ECO's Nos. 3, 4, and 11 through 22 should all be implemented by training the kitchen staff. All of these ECO's, while clearly energy savers, are difficult, if not impossible, to evaluate for energy savings. There are, simply, too many assumptions which would have to be made to evaluate these ECO's for the calculated savings to be meaningful. In addition, most O&M ECO's are very low in cost or are of no capital cost at all. The only cost associated with many of these ECO's is the cost of training the kitchen staff.

5.3.3 The following operating and maintenance deficiencies were observed at Vilseck during the site survey team's stay there.

1. A broken door closer was observed on one of the double doors at the troop entry. This door stood open during the entire six hour period of the site survey team's visit. During that time the outdoor air temperature averaged 40-45°F.

The air curtain over the open door did not operate. However, the air curtain over the opposite door cycled on and off continuously.

2. Every light in the facility was turned on and left on for the entire day.

3. The exhaust hoods over the serving lines operated continuously, even when no cooking or serving was being done.

4. Several empty tray warming units were turned but were never loaded and never used.

5. The rear door (to the loading dock) was open for the entire length of the site visit.

6. The lighting level in the beverage and dessert areas was excessive.

7. The external duct insulation in the attic spaces was no longer affixed to the ductwork in many places. Large areas of this insulation were lying on the floor. In other areas, the external duct insulation has been torn and/or crushed by unused cooking equipment and seasonal materials which have been stored on top of the ductwork. Ductwork should not be used as a storage shelf.

8. Several refrigerators were operating without any food stored in them.

5.3.4 Making these minor repairs or changing the Dining Facility's operating policy would help to reduce the building's energy consumption without significantly impacting the cost of operating the building.

5.3.5 The Army should, on a regular basis, update the training of the Dining Facility staffs - both cooking and maintenance staffs - as to energy saving practices. In addition, the Army should re-evaluate the use of the Dining Facility. Specifically, does the number

of meals served warrant the number of hours that the building is kept open? Can the baking staff work between meals or during the cleanup period rather than at night? Can one dining area be left unused during low volume meals such as breakfast and weekend meals? These practices can yield significant energy savings without affecting the facility's mission if they are implemented carefully.

5.4 ECO's Rejected for Grafenwöhr Building 101

5.4.1 The following ECO was rejected after a rigorous investigation of its merits. Rejection was based on the ECO having a Savings-to-Investment Ratio (SIR) of less than 1.0. That is, the savings (in DM) generated by the ECO's would not even pay for the ECO's installation.

TABLE EST-5 ECO'S REJECTED - GRAFENWOHR BUILDING 101

ECO NO.	ENERGY SAVINGS (MBTU/YR)*	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
E7	78.8	E	3,280	243,152	0.16	74.1

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.4.2 In some instances ECO's were rejected without a formal, cost vs. benefits analysis. Engineering experience and/or the particular situation or installation at Grafenwöhr Building 101 indicated that these ECO's were either impractical or impossible to install at this site. All of the ECO's rejected on this basis are listed below. An explanation of the basis for rejection follows the ECO description. Note that Operations and Maintenance (OM) type ECO's are not include din this list. This is due to the difficulty in accurately evaluating these types of ECO's and the uncertainty inherent in the results.

A1 Conserve energy by increasing the insulation in exterior walls.

Building 101 was designed with 6 centimeters of fiberglass batt insulation in the wall cavity between the outer brick wythe and the inner concrete block wythe of the exterior wall. This exceeds the 5cm of insulation required by the "Standard Design Guidelines for Modifying Interior and Exterior Energy Systems" published by the Utilities and Energy Branch HQ, USAREUS. See Table 1-1. Additional insulation would have only a marginal effect on the thermal characteristics of the exterior walls and would be enormously expensive since it would have to be installed on either the exterior of the building (using a system similar to the Dryvit system) or on the interior surface of the existing plaster wall. The new interior insulation would, then, have to be covered with new wood paneling and/or a new gypsum board interior wall.

A2 Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.

Building 101 was designed with 12cm of rigid board roof insulation. Assuming that the insulation is a typical, expanded polystyrene board (R=5.0/inch), the R-value of the roof assembly is estimated to be 25.18 °F-ft^2-hr/BTU. Increasing the R-value of the roof from the present R-25 to R-30 would have only marginal impact on the roof's thermal characteristics. Because the roof is only ten years old, the cost of re-roofing would more than offset any thermal improvement. However, when re-roofing is required, the roof insulation should be increased to achieve a rating of R-30 for the roof assembly.

A3 Conserve energy by reducing the amount of window glass in exterior walls

As presently configured, Building 101 has a glass-to-wall ratio of only 7.0 percent. There is little reason to reduce this ratio even further. The only significant amount of glazing in the building is in the dining area. Reducing this glass area further would reduce the architectural attractiveness of the dining space.

A4 Conserve energy by installing insulated panels over exterior windows

See commentary on ECO A3.

A5 Conserve energy by replacing single pane window glass with double or triple pane window glass.

The existing windows are already glazed with double pane, insulating window glass. Increasing the thermal efficiency of the windows by installing triple pane glass would only have a marginal effect on the thermal efficiency of the building.

A6 Conserve energy by installing storm windows over exterior windows.

See commentary on ECO A5.

A7 Conserve energy by installing solar film on exterior windows.

During the summer months, solar film does an excellent job of limiting solar heat gain and reducing the air conditioning load. However, since Building 101 is not air conditioned, solar film would have little energy conserving benefit. During the winter months, the lack of solar film (existing condition) allows

solar energy to enter the dining area. This tends to reduce the amount of heating required to keep the dining area comfortable. In this case, the lack of solar film is a benefit.

A8 Conserve energy by installing shades, screens, curtains, or blinds on exterior windows.

The windows at Grafenwöhr Building 101 are already outfitted with interior curtains. See, also, commentary on ECO A7.

A9 Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.

The weatherstripping and caulking on Building 101 was found to be in good condition.

A10 Conserve energy by installing vestibules at troop entrances.

Building 101 is already equipped with an entry vestibule at the troop entrance. Exterior doors not equipped with vestibules are all marked with "Emergency Exit Only" signs.

A11 Conserve energy by installing air curtains or plastic strips at all service entrances.

Current practice at Building 101 is to leave the kitchen make-up air unit "off" even when the kitchen hood exhaust fans are turned "on". This is done in all but the coldest weather. Since the units supplying make-up air to the kitchen and the dining area are not turned on, the make-up air for the exhaust hoods is drawn into the building through the screened rear (service entrance) doors. Since this practice seems to work satisfactorily, it is likely to be continued.

Therefore, an air curtain or plastic door strips, which would reduce the amount of air infiltrating into the building would be undesirable. Since the amount of outside air drawn into the building is the same, whether it is infiltration or ventilation air supplied by the make-up air units, the building's energy consumption remains constant. During extremely cold weather, the kitchen ventilation unit is turned "on" and the rear entry doors are kept closed. So air curtains or door strips would be of little use under this condition, also.

A12 Conserve lighting energy by improving the reflectivity of room surfaces.

Wall and ceiling surfaces at Grafenwöhr Building 101 were found to be of a light color and kept clean. Therefore, there is little opportunity for conserving energy by improving surface reflectivity.

H1 Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.

Energy saving exhaust hoods are already installed in Building 101.

H2 Conserve energy by recovering waste heat from exhaust air streams.

The energy-saving exhaust hoods installed in Building 101 (See commentary on ECO H1) have exhaust air streams with a very low heat content since most of the air being exhausted is outdoor air. For this reason, there is very little potential for exhaust air heat recovery. The toilet room exhaust has a somewhat higher heat content (higher temperature) but it has a very low flow rate and a low number of operating hours. Therefore, the potential for heat recovery from toilet room exhaust is, also, very low.

H3 Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.

Because two of the air handling units (kitchen and serving line units) are rarely turned on and because the building is not air conditioned, there is little or no potential energy savings expected from converting to VAV operation. VAV operation is particularly effective in reducing energy consumption when the HVAC system is operating in the air conditioning mode. However, it is not particularly effective in reducing energy consumption during the heating season. This is due to the fact that building heating is accomplished, primarily, through the perimeter radiation system.

H4 Conserve energy by balancing the HVAC system.

There were no unexpected or extreme temperature variations within the dining areas of Building 101. This indicates that the air supplied to the area is well suited to the requirements of that space. (Note that under normal operating conditions, only the air handling unit supplying the dining area is used). Therefore, it appears that the HVAC system does not require re-balancing.

H5 Conserve energy by reducing the amount of air supplied or exhausted from the building (or space).

An investigation of the existing drawings suggests that the present air flow rates are at or below the DIN requirements and the VDI guidelines. However, since the supply and exhaust air quantities of the existing HVAC system appear to be satisfactory for both comfort and odor control, there is little reason to re-balance the system.

H6 Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.

As noted previously, the air handling units serving the kitchen and the serving area are rarely used. Therefore, no energy savings can be derived from reducing the ventilation air flow rate of these units. The outdoor air damper on the dining area air handling unit appears to be operating properly to control the amount of ventilation air being supplied to the space and to minimize energy consumption.

H7 Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).

Low-leakage dampers are already present on the air handling equipment installed in Building 101.

H8 Conserve energy by reducing static pressure in HVAC systems.

The air handling unit serving the dining area appears to be operating satisfactorily. (See commentary on ECO H4). Since the system is a constant volume system, there are no VAV boxes which require some additional minimum static pressure at the box inlet. Therefore, the system static pressure is already at or near its optimum setting.

H9 Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.

There were no large or obvious leaks in the visible portions of the supply air ductwork or at the air handling unit casings at Building 101.

H10 Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.

The insulation on the visible portions of the HVAC system ductwork in Grafenwöhr Building 101 appeared to be intact and in good repair. Only minor repairs are required where the vapor barrier (external skin) of the insulation has been punctured or where seam tape has come unglued.

H11 Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.

The ceilings in Building 101 are between 2.99m. and 3.25m. high. These ceilings are too low for the interior spaces to have serious stratification problems. They are also somewhat low to have surface mounted recirculation fans installed below them.

H12 Conserve energy by recovering waste heat from refrigeration systems.

The most effective way to capture waste heat from refrigeration systems is to use a heat exchanger to preheat domestic hot water with the refrigerant hot gas. However, because the domestic hot water storage tank temperature (60°C) is greater than the hot gas temperature (± 43°C) of the refrigerator/freezer refrigeration systems, an additional hot water storage tank would have to be installed to allow heat to be recovered from the food storage refrigeration equipment. This tank would be used to pre-heat domestic water before it entered the existing hot water storage tank. However, there is not enough space in either the mechanical room or the refrigeration compressor room for such a storage tank.

H13 Conserve energy by ventilating the refrigeration system compressor room.

The compressor room in Building 101 is already equipped with a ventilation system. This consists of an intake louver in the east wall of the room and a roof-mounted exhaust fan.

H14 Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.

Given the age of Building 101 and the installed equipment, replacement of the refrigeration compressors would be impractical for two reasons. One, the equipment is less than half way through its useful life; and, two, the installed equipment should have a relatively high coefficient-of-performance (COP).

H15 Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.

The building automation system installed in Building 101 is already programmed to perform these functions.

H16 Conserve energy by reducing pump flow rates.

The building automation system installed in Building 101 is already programmed to adjust hot water flow rates - using the installed variable speed Wilo pumps - to suit the building's loads.

H18 Conserve energy by repairing or eliminating all HVAC control deficiencies.

According to building operating personnel, the installed building controls are operating properly.

H19 Conserve energy by using an Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.

According to building operating personnel, the installed EMCS is presently used to optimize equipment performance and building comfort.

H20 Conserve energy by using an EMCS to set-back space temperatures at night during the heating season.

See commentary on ECO H19.

H21 Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.

The occupancy schedule for this building is well defined. Therefore, the ventilation system can be controlled effectively by the EMCS and the addition of space occupancy sensors is unnecessary.

H22 Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.

It has been determined that re-wiring the existing cooking equipment to turn the associated exhaust hoods "on" and "off" is impractical. However, training the kitchen staff to operate cooking hoods only while cooking is a viable low/no cost ECO, and will be dealt with as an O&M ECO.

H23 Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.

The air handling units in Building 101 are not equipped for air conditioning. Therefore, economizer cycle controls are not necessary.

H24 Conserve energy by shutting off or reducing the amount of heating in vestibules.

The only vestibule in Building 101 (at the troop entrance to the building) is not equipped with any heating devices.

H25 Conserve energy by installing a thermal storage system.

Thermal storage systems are only practical for buildings equipped with air conditioning. Even then they are only viable when there are significant time-of-day incentives (from the power supplier) for consuming more power during off-peak periods and less power during peak demand periods. Since neither of these criteria are met at Grafenwöhr, there is little reason to install a thermal storage system.

H26 Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.

Infrared heaters are best suited for exterior area heating (such as loading docks) or for areas with extremely large volumes (such as warehouses). Since neither of these types of spaces are present in Building 101 there is little reason to pursue the use of infrared heating.

P1 Conserve energy by lowering the domestic hot water supply temperature.

The hot water storage temperature of 60°C is required by Army regulations.

P2 Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak hours.

The required controls are already present on the Building 101 domestic hot water system.

P3 Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.

The largest, single hot water consumer is the dishwasher, which is already equipped with an electric booster heater.

P4 Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.

Given the relatively recent construction of Building 101, the replacement of the existing water heating equipment with instantaneous water heaters is highly impractical. In addition, heating domestic water with electricity is more expensive (in both cost and energy terms) than heating with district hot water - as is presently done.

P6 Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.

The insulation for the domestic hot water system requiring repair is located in the central mechanical space. This insulation has been evaluated as part of ECO H17.

P9 Conserve energy by reclaiming waste heat from dishwasher wastewater.

The present dishwasher installation would make it extremely difficult to connect a water-to-water heat exchanger to the sanitary sewer connection on the dishwasher. Also, there is little space in the mechanical room for installing the additional pumps and secondary loop heat exchanger required to recover heat from the dishwasher wastewater.

P10 Conserve energy by installing solar collectors to pre-heat domestic hot water.

The total insolation (time and intensity of sunshine) in Grafenwöhr makes solar heating technically impractical.

E2 Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.

The lighting fixtures in Building 101 are spaced in such a manner that no fixtures can be eliminated without causing undesirable variations in the lighting levels within individual spaces.

E3 Conserve energy by de-lamping selected fixtures.

See ECO E1. In some areas, selective de-lamping, rather than re-lamping with lower wattage lamps, may be the most cost effective method for reducing lighting levels to the required minimum.

E4 Conserve energy by converting existing lighting fixtures to high efficiency fluorescent or HID fixtures.

Both the interior and exterior fixtures at Grafenwöhr Building 101 are already either fluorescent (interior) or HID (exterior) type. Incandescent lighting is not used in this building.

E5 Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.

This has already been done in Building 101.

E6 Conserve energy by installing improved reflectors on lighting fixtures and reducing the fixtures lamp wattage.

The lighting fixtures in Grafenwöhr Building 101 are relatively new fixtures which are already equipped with efficient reflectors and low wattage lamps.

E7 Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.

A rigorous elevation of this ECO resulted in Savings-to-Investment Ratio of less than 1.0. Therefore, the ECO has been rejected.

E8 Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.

For architectural reasons, the fixtures in Building 101 are not suitable for re-lamping with U-tube fluorescent lamps.

E9 Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.

See commentary on ECO E8.

E11 Conserve energy by turning exterior lighting "on" and "off" by means of photocells.

ECO E10 has been developed to minimize the energy used for exterior lighting. Photocells have been included in the development of ECO E10.

E12 Conserve energy by turning exterior lighting "on" and "off" by means of timers.

ECO E10 has been developed to turn the exterior lighting "on" and "off" by means of a photocell. Therefore, this ECO will not be pursued. See, also, ECO E11.

E13 Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.

Because the Dining Facility is not a multiple use facility (i.e., the spaces are all designed for a single specific activity) task level switching is not appropriate for this building.

E15 Conserve energy by turning interior lighting "on" and "off" by means of timers.

ECO E14 has been developed to minimize energy usage within the Dining areas. Therefore, this ECO will not be pursued.

E16 Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.

ECO E14 has been developed to turn the interior lighting "on" and "off" by means of a timer. Therefore, this ECO will not be pursued. See, also, ECO E15.

E17 Conserve energy by replacing existing motors with energy efficient motors.

Given the relatively short period of time that the existing motors have been in service, it would be both expensive and wasteful to replace them with newer motors. In addition, the efficiency of newer motors is only marginally better than that of motors built less than ten years ago.

E18 Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.

On inspection, the large (greater than 1/2 HP) motors at Grafenwöhr Building 101 were found to be well matched to their service loads.

E19 Conserve energy by adding power factor correcting capacitors to existing motors.

The motors on equipment installed in Building 101 are well suited for their service and do not require power factor correction.

E20 Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.

The only motors which are subjected to this type of loading are the hot water pumps. These pumps are already equipped with variable frequency drives.

5.5 ECO's Rejected for Vilseck Building 603

5.5.1 The following ECO's were rejected after a rigorous investigation of their merits. Rejection was based on the ECO's having a Savings-to-Investment Ratio (SIR) of less than 1.0 or a payback of greater than 10 years.

TABLE EST-6 ECO'S REJECTED - VILSECK BUILDING 603

ECO NO.	ENERGY SAVINGS (MBTU/YR)	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P8	6.8	DHW	245	2,822	1.50	11.5
E14	9.8	E	402	4,952	0.94	12.3
E10	1.1	E	43.5	1,240	0.41	28.2
H10	1.4	DHW	50	2,436	0.36	48.2
E7	79.4	E	3,257	237,328	0.16	72.9

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.5.2 The following ECO's were rejected for implementation at Vilseck Building 603 without the benefit of a formal cost vs. benefit analysis. The reason for the rejection follows the ECO description. Note that Operations and Maintenance (OM) ECO's are not included in this list. This is due to the difficulty in accurately evaluating these types of ECO's and the uncertainty in the results.

A1 Conserve energy by increasing insulation in exterior walls.

Building 603 was designed with 6 centimeters of fiberglass batt insulation in the wall cavity between the outer brick wythe and the inner concrete block wythe of the exterior wall. This exceeds the 5cm of insulation required by the "Standard Design Guidelines for Interior and Exterior Energy Systems" published by the Utilities and Energy Branch, HQ, USAREUS. See Table 1-1. Additional insulation would have only a marginal effect on the thermal characteristics of the exterior walls and would be enormously expensive since it would have to be installed on either the exterior of the building (using a system similar to the Dryvit system) or on the interior surface of the existing plaster wall. The new interior insulation would, then, have to be covered with new wood paneling and/or a new gypsum board interior wall.

A2 Conserve energy by adding roof or ceiling insulation to the building to achieve a thermal resistance (R) rating of at least R-30 for the combined ceiling elements.

Building 603 was designed with 12cm of fiberglass batt roof insulation. The R-value of the roof assembly is estimated to be 20.93 °F-ft^2-hr/BTU. Increasing the R-value of the roof from the present R-21 to R-30 would improve the roof's thermal characteristics, but would be very expensive. Because the roof is less than ten years old, the cost of re-roofing would more than offset any thermal improvement. However, when re-roofing is required, the roof insulation should be increased to achieve a rating of R-30 for the roof assembly.

A3 Conserve energy by reducing the amount of window glass in exterior walls

As presently configured, Building 603 has a low ratio of glass-to-wall. There is little reason to reduce this ratio even further. The only significant amount of glazing in the building is in the dining area. Reducing this glass area further would reduce the architectural attractiveness of the dining space.

A4 Conserve energy by installing insulated panels over exterior windows

See commentary on ECO A3.

A5 Conserve energy by replacing single pane window glass with double or triple pane window glass.

The existing windows are already glazed with double pane, insulating window glass. Increasing the thermal efficiency of the existing windows by installing triple pane glass would only have a marginal effect on the overall thermal efficiency of the building envelope.

A6 Conserve energy by installing storm windows over exterior windows.

See commentary on ECO A5.

A7 Conserve energy by installing solar film on exterior windows.

During the summer months, solar film does an excellent job of limiting solar heat gain and reducing the air conditioning load. However, since Building 603 is not air conditioned, solar film would have little energy conserving benefit. During the winter months, the lack of solar film (existing condition) allows solar energy to enter the dining area. This tends to reduce the amount of

heating required to keep the dining area comfortable. In this case, the lack of solar film is a benefit.

A8 Conserve energy by installing shades, screens, curtains, or blinds on exterior windows.

The windows at Vilseck Building 603 are already equipped with interior curtains. See, also, commentary on ECO A7.

A9 Conserve energy by reducing infiltration by means of new or improved weatherstripping and/or caulking.

The weatherstripping and caulking on Building 603 was found to be in good condition.

A10 Conserve energy by installing vestibules at troop entrances.

Building 603 is already equipped with an entry vestibule at the troop entrance. Exterior doors not equipped with vestibules are all marked with "Emergency Exit Only" signs.

A11 Conserve energy by installing air curtains or plastic door strips at all service entrances.

Current practice at Building 603 is to have make-up air for the kitchen exhaust hoods brought into the building through the ventilation system. This keeps the building at a neutral pressure with the respect to the outdoors. Therefore, an air curtain or plastic door strips would do little to reduce the building's energy consumption.

A12 Conserve lighting energy by improving the reflectivity of room surfaces.

Wall and ceiling surfaces at Vilseck Building 603 were found to be of a light color and kept clean. Therefore, there is little opportunity for conserving energy by improving surface reflectivity.

H1 Conserve energy by installing energy efficient exhaust hoods with integral make-up air ducts.

Energy saving exhaust hoods are already installed in Building 603.

H2 Conserve energy by recovering waste heat from exhaust air streams.

The energy-saving exhaust hoods installed in Building 603 (See commentary on ECO H1) have exhaust air streams with a very low heat content since most of the air being exhausted is outdoor air. For this reason, there is very little potential for exhaust air heat recovery. The toilet room exhaust has a somewhat higher heat content (higher temperature) but it has a very low flow rate and a low number of operating hours. The dishwasher exhaust has an even greater total heat content, but an even lower number of operating hours. Therefore, the potential for heat recovery from the toilet room exhaust and the dishwasher exhaust is, also, very low.

H3 Conserve energy by changing constant volume air handling units to variable air volume (VAV) operation.

Because Building 603 is not air conditioned, there is little or no potential energy savings expected from converting to VAV operation. VAV operation is particularly effective in reducing energy consumption when the HVAC system is operating in the air conditioning mode. However, it is not particularly effective in reducing energy consumption during the heating

season. This is due to the fact that building heating is accomplished, primarily, through the perimeter radiation system.

H4 Conserve energy by balancing the HVAC system.

There were no unexpected or extreme temperature variations from area to area (or space to space) within Building 603. This indicates that the air supplied to each area (or space) is well suited to the requirements of that space. Therefore, it appears that the HVAC system does not require re-balancing.

H5 Conserve energy by reducing the amount of air supplied to or exhausted from the building (or space).

An investigation of the existing drawings suggests that the present air flow rates are at or below the DIN requirements and the VDI Guidelines. However, since the supply and exhaust air quantities of the existing HVAC system appear to be satisfactory for both comfort and odor control, there is little reason to re-balance the system.

H6 Conserve energy by reducing the amount of ventilation air drawn into the building by the HVAC system.

The outdoor air dampers on the air handling units in Building 603 appear to be operating properly to control the amount of ventilation air being supplied to the building interior. The HVAC system appears to be providing only the minimum amount of ventilation air required to make-up exhausted air and to ensure good air quality within the building.

H7 Conserve energy by installing tight-closing, low-leakage dampers on all outside air intake and exhaust openings (except at kitchen exhaust fans since damper blades could collect grease and become a fire hazard).

Low-leakage dampers are already present on the air handling equipment installed in Building 603.

H8 Conserve energy by reducing static pressure in HVAC systems.

The air handling units serving Building 603 appear to be operating satisfactorily. Since the HVAC system is a constant volume system, there are no VAV boxes which require some additional minimum static pressure at the box inlet. Therefore, the various HVAC systems are already operating at or near their optimum static pressure settings.

H9 Conserve energy by reducing supply air leakage at air handling units and supply air ductwork.

There were no large or obvious leaks in the visible portions of the supply air ductwork or in the air handling unit casings at Building 603.

H10 Conserve energy by insulating and/or repairing damaged insulation on HVAC system ductwork.

A rigorous evaluation of the ECO resulted in a Savings-to-Investment Ratio (SIR) of less than 1.0. Therefore, the ECO was rejected.

H11 Conserve energy by installing ceiling-mounted circulating fans to reduce stratification within occupied spaces.

The ceilings in Building 603 are too low for the interior spaces to have serious stratification problems. They are also somewhat low to have surface mounted recirculation fans installed below them.

H12 Conserve energy by recovering waste heat from refrigeration systems.

The most effective way to capture waste heat from refrigeration systems is to use a heat exchanger to preheat domestic hot water with the refrigerant hot gas. However, because the domestic hot water storage tank temperature (60°C) is greater than the hot gas temperature (± 43°C) of the refrigerator/freezer refrigeration systems, an additional hot water storage tank would have to be installed to allow heat to be recovered from the food storage refrigeration equipment. This tank would be used to pre-heat domestic water before it entered the existing hot water storage tank. However, there is not enough space in either the mechanical room or the refrigeration compressor room for such a storage tank.

H13 Conserve energy by ventilating the refrigeration system compressor room.

The compressor room in Building 603 is already equipped with a ventilation system. This consists of an intake louver in the south wall of the room and a roof-mounted exhaust fan.

H14 Conserve energy by replacing reciprocating type refrigeration compressors with higher efficiency scroll or rotary (screw) type compressors.

Given the age of Building 603 and the installed equipment, replacement of the refrigeration compressors would be impractical for two reasons. One, the equipment is less than half way through its useful life; and, two, the installed equipment should have a relatively high coefficient-of-performance (COP).

H15 Conserve energy by re-setting heating hot water temperature according to outside air temperature and occupancy schedules.

The building automation system installed in Building 603 is already programmed to perform these functions.

H16 Conserve energy by reducing pump flow rates.

The building automation system installed in Building 603 is already programmed to adjust hot water flow rates - using the installed variable speed Grundfos pumps - to suit the building's loads.

H18 Conserve energy by repairing or eliminating all HVAC control deficiencies.

According to building operating personnel, the installed building controls are operating properly.

H19 Conserve energy by using an Energy Monitoring and Control System (EMCS) to optimize the start-up and shut-down schedules for HVAC system fans, pumps, compressors, and other motorized devices.

According to building operating personnel, the installed building control system is presently used to optimize equipment performance and building comfort. The building control system will be connected, shortly, to the site-wide EMCS.

H20 Conserve energy by using an EMCS to set-back space temperatures at night during the heating season.

See commentary on ECO H19.

H21 Conserve energy by installing occupancy sensors to cycle the ventilation system "on" and "off" according to occupancy.

The occupancy schedule for this building is well defined. Therefore, the ventilation system can be controlled effectively by the existing building control system. The addition of space occupancy sensors is unnecessary.

H22 Conserve energy by interlocking the kitchen exhaust hoods with the cooking equipment served by each hood.

It has been determined that re-wiring the existing cooking equipment to turn the associated exhaust hoods "on" and "off" is impractical. However, training the kitchen staff to operate cooking hoods only while cooking is a viable low/no cost ECO, and will be dealt with as an O&M ECO.

H23 Conserve energy by installing economizer cycle controls and dampers on all ventilation systems.

The air handling units in Building 603 are not equipped for air conditioning. Therefore, economizer cycle controls are not necessary.

H25 Conserve energy by installing a thermal storage system.

Thermal storage systems are only practical for buildings equipped with air conditioning. Even then they are only viable when there are significant time-of-day incentives (from the power supplier) for consuming more power during off-peak periods and less power during peak demand periods. Since neither of these criteria are met at Vilseck, there is little reason to install a thermal storage system.

H26 Conserve energy by using infrared heaters in lieu of conventional (convection) heaters.

Infrared heaters are best suited for exterior area heating (such as loading docks) or for areas with extremely large volumes (such as warehouses). Since neither of these types of spaces are present in Building 603, there is little reason to pursue the use of infrared heating.

P1 Conserve energy by lowering the domestic hot water supply temperature.

The hot water storage temperature of 60°C is required by Army regulations.

P2 Conserve energy by installing controls on the domestic hot water system to lower the heater's set-point temperature or to shut-off the heat source to the heater during non-peak hours.

The required controls are already present on the Building 603 domestic hot water system.

P3 Conserve energy by installing booster heaters at major hot water users and at high temperature hot water users.

The largest, single hot water consumer is the dishwasher, which is already equipped with an electric booster heater.

P4 Conserve energy by installing instantaneous hot water heaters in lieu of storage tank type heaters.

Given the relatively recent construction of Building 603, the replacement of the existing water heating equipment with instantaneous water heaters is highly impractical. In addition, heating domestic water with electricity is more expensive (in both cost and energy terms) than heating with district hot water - as is presently done.

P6 Conserve energy by installing additional insulation and/or repairing existing insulation on domestic hot water piping.

The insulation for the domestic hot water system requiring repair is located in the central mechanical space. This insulation has been evaluated as part of ECO H17.

P8 Conserve energy by installing automatic shut-off type faucets in lavatories.

A rigorous evaluation of this ECO resulted in a payback period of greater than 10 years. Therefore, the ECO was rejected.

P9 Conserve energy by reclaiming waste heat from dishwasher wastewater.

The present dishwasher installation would make it extremely difficult to connect a water-to-water heat exchanger to the sanitary sewer connection on the dishwasher. Also, there is little space in the mechanical room for installing the additional pumps and secondary loop heat exchanger required to recover heat from the dishwasher wastewater.

P10 Conserve energy by installing solar collectors to pre-heat domestic hot water.

The total insolation (time and intensity of sunshine) in Vilseck makes solar heating technically impractical.

E2 Conserve lighting energy by eliminating excess fixtures. Where fixtures are close enough to each other, it may be possible to eliminate excess fixtures without creating dark spots.

The lighting fixtures in Building 603 are spaced in such a manner that no fixtures can be eliminated without causing undesirable variations in the lighting levels within individual spaces.

E3 Conserve energy by delamping selected fixtures.

See ECO E1. In some areas, selective de-lamping, rather than re-lamping with lower wattage lamps, may be the most cost effective method for reducing lighting levels to the required minimum.

E5 Conserve energy by replacing the incandescent lamps in exit lights with lower wattage fluorescent lamps.

This has already been done in Vilseck Building 603.

E6 Conserve energy by installing improved reflectors or lighting fixtures and reducing the fixtures lamp wattage.

The lighting fixtures in Vilseck Building 603 are relatively new fixtures which are already equipped with efficient reflectors and low wattage lamps.

E7 Conserve energy by replacing existing core coil ballasts with electronic ballasts in existing fluorescent lighting fixtures.

A rigorous evaluation of this ECO resulted in a Savings-to-Investment Ratio of less than 1.0. Therefore, the ECO was rejected.

E8 Conserve energy by replacing existing lamps with energy efficient U-tube fluorescent lamps.

For architectural reasons, the fixtures in Building 603 are not suitable for re-lamping with U-tube fluorescent lamps.

E9 Conserve energy by replacing existing incandescent bulbs with compact fluorescent bulbs.

See commentary on ECO E8.

E10 Conserve energy by installing dimming hardware on exterior HID lighting.

A rigorous evaluation of this ECO resulted in a Savings-to-Investment Ratio of less than 1.0. Therefore, the ECO was rejected.

E11 Conserve energy by turning exterior lighting "on" and "off" by means of photocells.

ECO E10 has been developed to minimize the energy used for exterior lighting. Photocells have been included in the development of ECO E10.

E12 Conserve energy by turning exterior lighting "on" and "off" by means of timers.

ECO E10 has been developed to turn the exterior lighting "on" and "off" by means of a photocell. Therefore, this ECO will not be pursued. See, also, ECO E11.

E13 Conserve energy by providing task level switching for interior lights. Task level switching will allow the lighting level to be varied to match the activity within the space.

Because the Dining Facility is not a multiple use facility (i.e., the spaces are all designed for a single, specific activity) task level switching is not appropriate for this building.

E14 Conserve lighting energy by using photocells to turn "Off" or dim interior lights (especially lights near windows) when natural daylight provides adequate illumination.

This ECO was subjected to a rigorous economic evaluation (see Tab 6 of Volume III). It was eliminated because the calculated Savings-to-Investment Ratio (SIR) of 0.94 is less than 1.0.

E15 Conserve energy by turning interior lighting "on" and "off" by means of timers.

ECO E14 which contained this ECO, was evaluated and found to be too expensive for implementation. Therefore, this ECO will not be pursued.

E16 Conserve energy by turning interior lighting "on" and "off" by means of space occupancy sensors.

This ECO will not be pursued. See, explanation of ECO E14 and ECO E15.

E17 Conserve energy by replacing existing motors with energy efficient motors.

Given the relatively short period of time that the existing motors have been in service, it would be both expensive and wasteful to replace them with newer motors. In addition, the efficiency of newer motors is only marginally better than that of motors built less than ten years ago.

E18 Conserve energy by replacing oversized/undersized motors with motors which have their peak efficiency at the actual system load.

On inspection, the large (greater than 1/2HP) motors at Vilseck Building 603 were found to be well matched to their service loads.

E19 Conserve energy by adding power factor correcting capacitors to existing motors.

The motors on equipment installed in Building 603 are well suited for their service and do not require power factor correction.

E20 Conserve energy by equipping motors which experience highly variable loads with variable frequency drives.

The only motors which are subjected to this type of loading are the hot water pumps. These pumps are already equipped with variable frequency drives.

5.6 ECIP Projects Developed for Grafenwöhr Building 101

5.6.1 No ECIP projects were developed for implementation at Grafenwöhr Building 101.

5.7 ECIP Projects Developed for Vilseck Building 603

5.7.1 No ECIP projects were developed for implementation at Vilseck Building 603.

5.8 Non-ECIP Projects Developed for Grafenwöhr Building 101

5.8.1 The following Non-ECIP projects have been identified as energy saving opportunities for implementation at Grafenwöhr Building 101. These projects all have Savings-to-Investment Ratios (SIR) greater than 1.0 and paybacks of less than 10 years. Note: All ECO's listed in the Table below ere evaluated in FY93 for implementation in FY93.

TABLE EST-7 Non-ECIP Projects - Grafenwöhr Building 101

ECO NO.	ENERGY SAVINGS (MBTU/YR)*	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	87.2	DHW	2,669	32	1,418	<0.1
E1	24.8	E	1,031	808	14.79	1.3
P5	5.5	DHW	169	549	5.30	3.2
P8	5.2	DHW	159	1,210	2.26	7.6
E10	9.2	E	381	1,546	2.85	4.1
H17	6.4	DHW	196	3,226	1.04	16.5
E14	7.4	E	309	3,552	1.01	11.5

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.8.2 Complete documentation for each Non-ECIP project listed above can be found in Appendix D of Volume III of this report.

5.9 Non-ECIP Projects Developed for Vilseck Building 603

5.9.1 The following Non-ECIP projects have been identified as energy saving opportunities for implementation at Vilseck Building 603. These projects all have Savings-to-Investment Ratios (SIR) of greater than 1.0 and paybacks of less than 10 years. Note: All ECO's listed in the Table below were evaluated in FY93 for implementation in FY93.

TABLE EST-8 Non-ECIP Projects - Vilseck Building 603

ECO NO.	ENERGY SAVINGS (MBTU/YR)*	FUEL **	COST SAVINGS (DM/YEAR)	COST (DM)	SIR	PAYBACK (YEARS)
P7	113.3	DHW	4,087	75	935	<0.1
E4B	39.6	E	1,624	18,827	15.01	0.8
H24	1.0/30.3	E/DHW	1,134	1,344	14.35	1.2
E1	44.5	E	1,825	2,020	10.47	1.1
P5	8.8	DHW	318	878	6.24	2.8
E14	9.8	E	402	768	6.07	1.9
H17	40.7	DHW	1,468	9,588	2.64	6.5
E4A	195.0	E	7,999	74,432	1.24	9.3

* MBTU = 10^6BTU's
** Fuel types are: Electricity (E) and District Hot Water (DHW)

5.9.2 Complete documentation for each Non-ECIP project listed above can be found in Appendix D in Volume III of this report.

5.10 Low/No Cost Projects for Grafenwöhr Building 101

5.10.1 ECO's OM3, OM4, and OM11 through OM22 have been identified as energy saving opportunities with little or no implementation costs. These items, for the most part, can be implemented through the training and cooperation of the Dining Facility staff.

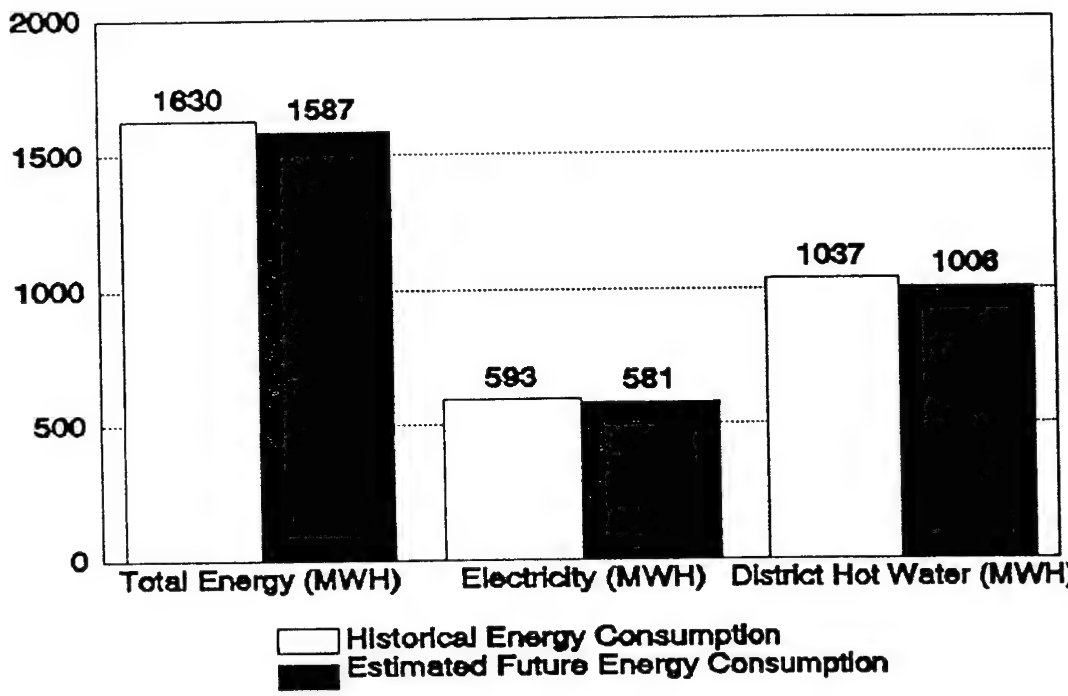
5.11 Low/No Cost Projects for Vilseck Building 603

5.11.1 ECO's, OM3, OM4, and OM11 through OM22 have been identified as energy saving opportunities with little or no implementation costs. These items, for the most part, can be implemented through the training and cooperation of the Dining Facility staff.

TAB 6 - ENERGY AND COST SAVINGS

6.1 Total Potential Energy and Cost Savings - Grafenwöhr Building 101

6.1.1 If all of the energy saving recommendations made for Grafenwöhr Building 101 were put into effect, the total energy expenditure for the building would be reduced by 30,600 kWh, annually. This is a 2.6% reduction in total energy consumption. The cost of energy would be reduced by DM 4,914 which is a 2.5% cost reduction.

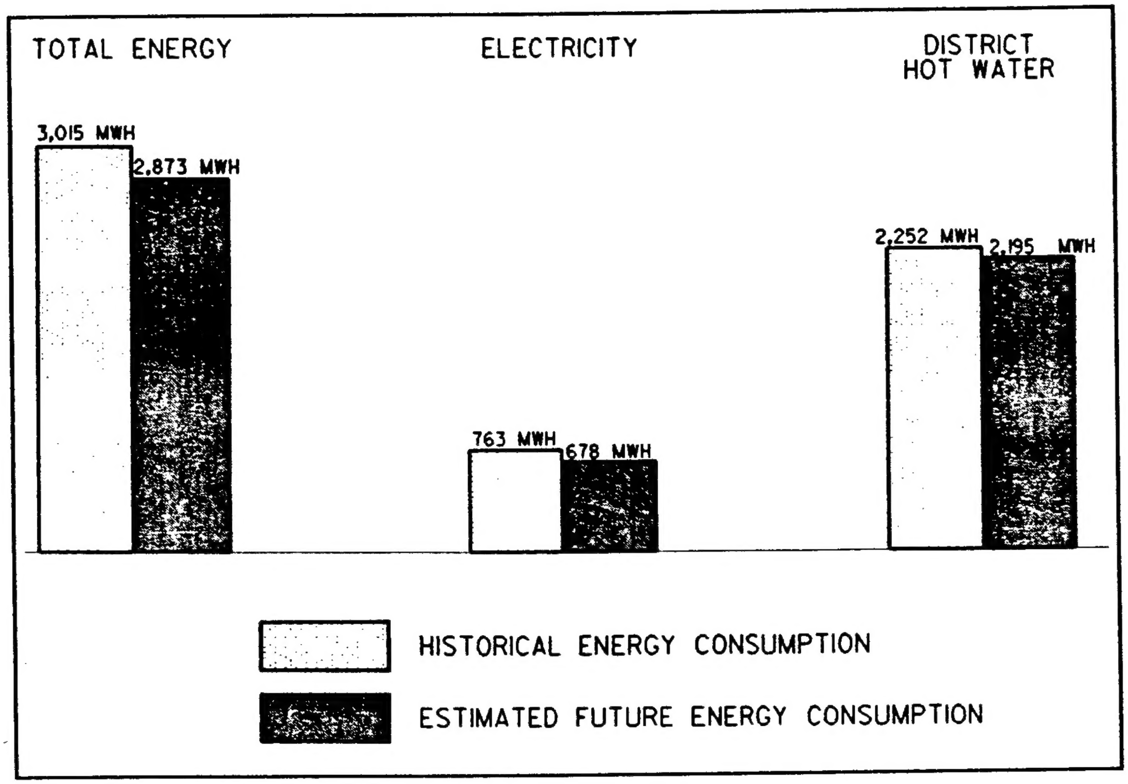


ESF-5 Energy Savings - Grafenwöhr Building 101.

6.2 Total Potential Energy and Cost Savings - Vilseck Building 603

6.2.1 If all of the energy saving recommendations made for Vilseck Building 603 were put into effect, the total energy expenditure for the building would be reduced by 141,518 kWh,

annually. This is a 4.7% reduction in total energy consumption. The cost of energy would be reduced by DM 18,857 which is a 5.5% cost reduction.



ESF-6 Energy Savings - Vilseck Building 603.

TAB 7 - ANALYSIS OF ENERGY SERVICE TO THE SITE

7.1 Description of Work

7.1.1 In addition to the analysis of the two dining facilitates, the audit team agreed to look at the electrical and district hot water services entering the site. In doing this, the audit team looked at the billing data collected by each Base and the utility contracts for each Base. The complete text of the site utility analysis can be found under Tab 7 of Volume III.

7.2 Reducing Electrical Service Costs

7.2.1 Substantial savings can be attained since the level of service cost is largely determined by the highest real (or effective) power used during any 15 minute period, for example:

If the service peak is lowered by 100 kva, the annual cost savings would be 100 kva x 230.40 DM/kva = DM 23,040.

The installation of energy optimization equipment particularly for resistance-type users in canteens would lower service peaks and therefore reduce service costs. Energy optimization equipment for use in canteens will cost about DM 50,000.00.

7.3 Reducing Electrical Power Costs

7.3.1 Power costs consist of:

High Demand Power Price (HT)

Low Demand Power Price (LT)

Reactive Power Price

Item 6 of the Contract suggests that the shifting of power use to a low demand period would result in savings of 2.40 D. Pfennig/kwh.

Since the total annual power usage at Grafenwöhr is 24,987,465 kwh, and the total annual power usage at Vilseck is 31,518,960 kwh, a shifting of only 5% of this use to a low demand period would result in an annual savings of about DM 70,000.

7.4 Reducing Power Factor Costs

7.4.1 If power is drawn at a power factor (PF) of less than 0.9, it is billed at an additional 3.60 D. Pfennig/kvarh. Further, the power factor influences the service cost. However, since the mean power factor in 1992 for Grafenwöhr was 0.998 and for Vilseck 0.991, power factor correction will not be required.

7.5 Reducing District Hot Water Costs

7.5.1 A thorough study of the District Hot Water Service contracts, conducted in conjunction with the User, produced no practical means for reducing energy costs.

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